Uttar Pradesh Journal of Zoology

Volume 44, Issue 19, Page 20-26, 2023; Article no.UPJOZ.2747
ISSN: 0256-971X (P)

Induction of Resistance in Bhendi Accessions against Whitefly, *Bemisia tabaci* (Gennadius) under Field Condition

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Authors' contributions

This work was carried out in collaboration between both authors. The research work was conceptualized by author NM and conducted by author JMS under the supervision of author NM. The manuscript was written by author JMS and edited by author NM. Both authors read and approved the final manuscript.

Article Information

DOI: 10.56557/UPJOZ/2023/v44i193612

Editor(s):
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Original Research Article

Received: 09/06/2023
Accepted: 12/08/2023
Published: 22/08/2023

ABSTRACT

Two bhendi accessions were screened for the induction of resistance by seed treatment with agriculturally beneficial microorganisms like *Azospirillum,* Phosphobacteria and K-solubilizer against whitefly, *Bemisia tabaci* (Genn.) at the Department of Entomology, Faculty of Agriculture, Annamalai University. Accession Salem Local along with Arka Anamika was screened with different agriculturally beneficial microorganisms under field condition. The nymphal population of whitefly

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was recorded during two (*Rabi* and *Kharif*) seasons of 2022. Among the treatments, the accession Salem Local treated with K- solubilizer recorded the lowest nymphal population followed by the treatment, *Azospirillum* + Phosphobacteria + K-solubilizer. Whereas the maximum nymphal population was observed in Arka Anamika treated with *Azospirillum* with the mean nymphal population of 3.32 and 3.65 in the *Rabi* and *Kharif* seasons respectively. Hence, the accessions following seed treatment that conferred resistance against whitefly were selected for breeding in order to develop whitefly resistant varieties.

Keywords: Agriculturally beneficial microorganisms; bhendi; B. tabaci; nymphal population.

1. INTRODUCTION

Bhendi (*Abelmoschus esculentus* L.) is an important source of Vitamins, Calcium, Potassium and other minerals, which are often lacking in the people's diet in developing countries. Additionally, reports of its medicinal value claim that it can treat ulcers and provide relief from haemorrhoids. Bhendi has found usage in medicine as a blood volume expander or plasma replacement, as well as for genito-urinary diseases, spermatorrhoea, and chronic dysentery [1]. A variety of sucking and fruit-boring pests have an impact on the growth and quality of bhendi fruits from the seedling stage to harvest [2]. The Whitefly, *Bemisia tabaci* (Genn.) one of the important sucking pests causes financial harm to bhendi by sucking on the phloem sap and polluting the leaves and fruits with honey dew, which leads to the formation of sooty mold. This limits foliar photosynthesis and lowers the crop's commercial value [3]. *B. tabaci* is a highly destructive insect pest all across the world [4,5]. Affected plants exhibit yellowing, folding of the leaf, poor plant development, and deformed fruit [6]. It also causes significant crop damage and yield losses due to direct feeding by both nymphs and adults. Many research throughout the world have attempted to mitigate its impact on long-term crop productivity [7-9]. Although foliar use of synthetic pesticides is critical for effective control of *B. tabaci*, it has adverse consequences such as environmental pollution, pest resistance and resurgence, pollinator toxicity, and agricultural yield penalty [10]. *B. tabaci* has the potential to become extremely resistant to insecticides, this species had shown resistance to more than 40 active ingredients of insecticides [11]. The uncontrolled use of insecticides raises production costs and leaves insecticidal residue in fruits and soil. As an alternative, genetically modified plants that are resistant to pests require little to no additional input cost and hence are given a lot of attention. The best method to handle pest problems is to use integrated pest management practises, of which host plant resistance is a key component. The management of insect pests, such as *B. tabaci* through host plant resistance is economically sensible and environmentally safe [12]. In the absence of natural resistance in the crop plants or lack of desirable yield attributes in the identified insect tolerant/ resistant crop varieties, inducing resistance by manipulation of plant nutrients may be attempted [13]. Induced resistance has been considered as a potential strategy for insect pests control in plants [14]. In general, both plant nutrition levels and insect pest attack could change plant metabolic, hormonal and signalling pathways, and these pathways could affect each other and have significant effects on plant susceptibility against insect pests [15]. Understanding relationship between plant nutrition and feeding and reproductive potential of pest is important for pest management in modern agro-ecosystems [16]. Therefore, the present study was aimed to induce resistance in bhendi accessions via agriculturally beneficial microorganisms that imparting resistance to whitefly under field condition.

2. MATERIALS AND METHODS

The field experiment was conducted at Vallampadugai village (11.35ºN and 79.70ºE) in Cuddalore District, Tamil Nadu in 2022. The seeds of the bhendi accessions were sown in the plot of 4 x 3 m size with spacing 60 x 45 cm. A randomized Block Design (RBD) with five replications was adopted. The seeds are mixed into a slurry (the required amount of inoculants for seed treatment is mixed with rice gruel) to ensure a uniform coating of agriculturally beneficial microorganisms over the seeds. After treatments the seeds were shade dried for 30 minutes. Details on the various inoculants used in the current study are provided in Table 1.

Observations on the nymph of whitefly, *B. tabaci* were recorded at weekly interval during morning hours on five plants. To record the population

Table 1. Treatments for the induction of resistance in bhendi accessions against *B. tabaci*

Sl. No.	Treatments	Dosage	Day of application	Method of application
1.	*Azospirillum*	3ml/kg of seed	Day before sowing	Seed treatment
2.	Phosphobacteria	3ml/kg of seed	Day before sowing	Seed treatment
3.	K – Solubilzer	3ml/kg of seed	Day before sowing	Seed treatment
4.	*Azospirillum* +Phosphobacteria	1.5ml+1.5ml/kg of seed	Day before sowing	Seed treatment
5.	Phosphobacteria + K – Solubilizer	1.5ml+1.5ml/kg of seed	Day before sowing	Seed treatment
6.	*Azospirillum* + K – Solubilizer	1.5ml+1.5ml/kg of seed	Day before sowing	Seed treatment
7.	*Azospirillum*+Phosphobacteria + K – Solubilizer	1ml+1ml+1ml/kg of seed	Day before sowing	Seed treatment
8.	Control	-	-	-

Table 2. Field screening of bhendi accessions as influenced by agriculturally beneficial microorganisms for resistance against *B. tabaci* - Season 1(*Rabi*)

Treatment	Nymphal Population																	
	15th day		22th day		29th day		36th day		43th day		50th day		57th day		64th day		Mean Population	
	SL	AA	SL	AA	SL	AA	SL	AA	SL	AA	SL	AA	SL	AA	SL	AA	SL	AA
Azospirillum	0.00 (1.00)	0.53 (1.24)	1.17 (1.47)	0.65 (1.28)	1.36 (1.53)	3.30 (2.07)	2.67 (1.91)	4.27 (2.29)	3.67 (2.15)	6.68 (2.76)	4.56 (2.34)	4.31 (2.29)	4.51 (2.33)	4.25 (2.27)	4.84 (2.41)	2.57 (1.88)	2.84	3.32
Phosphobacteria	0.00 (1.00)	0.35 (1.16)	0.00 (1.00)	0.97 (1.40)	0.51 (1.22)	1.61 (1.61)	0.59 (1.25)	3.88 (2.17)	1.69 (1.63)	3.43 (2.10)	2.71 (1.91)	2.19 (1.78)	3.40 (2.09)	1.83 (1.68)	4.22 (2.27)	1.10 (1.44)	1.64	1.92
K – Solubilzer	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.02 (1.01)	0.00 (1.00)	0.05 (1.02)	0.07 (1.03)	0.20 (1.09)	0.09 (1.04)	0.96 (1.39)	0.15 (1.07)	0.79 (1.33)	0.19 (1.09)	0.40 (1.18)	0.20 (1.09)	0.24 (1.11)	0.08	0.33
Azospirillum +Phosphobacteria	0.00 (1.00)	0.31 (1.14)	0.00 (1.00)	0.56 (1.24)	0.73 (1.31)	3.11 (2.02)	0.88 (1.37)	3.63 (2.14)	1.95 (1.71)	3.93 (2.20)	4.80 (2.40)	3.75 (2.16)	2.67 (1.89)	3.76 (2.17)	3.67 (2.14)	1.67 (1.63)	1.83	2.59
Phosphobacteria + K – Solubilizer	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.28 (1.13)	0.22 (1.10)	0.82 (1.34)	0.35 (1.16)	1.79 (1.66)	0.52 (1.23)	1.98 (1.72)	0.95 (1.39)	1.20 (1.48)	0.40 (1.18)	0.61 (1.27)	0.67 (1.29)	0.20 (1.09)	0.38	0.86
Azospirillum + K – Solubilizer	0.00 (1.00)	0.30 (1.13)	0.41 (1.18)	0.57 (1.25)	0.73 (1.31)	3.11 (2.01)	1.24 (1.49)	3.41 (2.09)	3.04 (2.00)	2.75 (1.92)	3.35 (2.07)	3.56 (2.13)	3.83 (2.18)	3.05 (2.00)	3.02 (2.00)	2.11 (1.73)	1.95	2.35
Azospirillum+ Phosphobacteria + K – Solubilizer	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.43 (1.19)	0.00 (1.00)	0.64 (1.28)	0.13 (1.06)	0.72 (1.30)	0.24 (1.11)	1.06 (1.43)	0.26 (1.12)	0.48 (1.21)	0.32 (1.15)	0.36 (1.16)	0.35 (1.16)	0.51 (1.23)	0.16	0.52
Control	0.00 (1.00)	0.31 (1.14)	1.48 (1.57)	0.63 (1.27)	1.93 (1.71)	3.81 (2.18)	3.28 (2.05)	6.50 (2.71)	4.48 (2.33)	1.87 (1.69)	5.48 (2.54)	2.41 (1.84)	5.39 (2.51)	3.71 (2.16)	4.23 (2.28)	1.89 (1.70)	3.28	2.64
C.D. (p = 0.05)	-	0.04	0.03	0.09	0.10	0.21	0.14	0.34	0.18	0.25	0.20	0.19	0.27	0.21	0.22	0.18		

Each value is a mean of five replications
Values in parentheses are square root transformation

Table 3. Field screening of bhendi accessions as influenced by agriculturally beneficial microorganisms for resistance against *B. tabaci* - Season 2 (*Kharif*)

Treatment	Nymphal Population																	
	15th day		22th day		29th day		36th day		43th day		50th day		57th day		64th day		Mean Population	
	SL	AA	SL	AA	SL	AA	SL	AA	SL	AA	SL	AA	SL	AA	SL	AA	SL	AA
Azospirillum	0.71 (1.30)	1.15 (1.46)	1.35 (1.53)	2.11 (1.76)	1.88 (1.69)	3.09 (2.02)	2.68 (1.91)	4.19 (2.27)	3.44 (2.10)	5.21 (2.49)	4.25 (2.29)	6.33 (2.70)	3.15 (2.03)	4.48 (2.34)	2.25 (1.80)	2.64 (1.90)	2.46	3.65
Phosphobacteria	0.00 (1.00)	0.11 (1.05)	0.28 (1.31)	0.36 (1.16)	0.39 (1.17)	0.59 (1.26)	0.51 (1.22)	0.93 (1.38)	0.81 (1.34)	1.31 (1.51)	1.39 (1.54)	1.53 (1.59)	0.69 (1.29)	1.09 (1.44)	0.19 (1.08)	0.53 (1.23)	0.53	0.81
K – Solubilzer	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.15 (1.07)	0.00 (1.00)	0.21 (1.10)	0.04 (1.02)	0.28 (1.13)	0.32 (1.14)	0.40 (1.18)	0.07 (1.03)	0.23 (1.10)	0.00 (1.00)	0.00 (1.00)	0.05	0.16
Azospirillum + Phosphobacteria	0.48 (1.21)	0.63 (1.27)	0.96 (1.39)	1.52 (1.57)	1.27 (1.49)	2.19 (1.78)	1.79 (1.66)	3.05 (2.01)	2.23 (1.79)	3.56 (2.13)	2.73 (1.93)	4.27 (2.29)	1.85 (1.68)	2.75 (1.92)	1.29 (1.51)	1.60 (1.60)	1.58	2.45
Phosphobacteria + K – Solubilizer	0.00 (1.00)	0.00 (1.00)	0.25 (1.12)	0.27 (1.12)	0.28 (1.13)	0.35 (1.16)	0.33 (1.15)	0.44 (1.20)	0.40 (1.18)	0.56 (1.24)	0.25 (1.12)	0.65 (1.28)	0.16 (1.07)	0.39 (1.17)	0.00 (1.00)	0.17 (1.08)	0.21	0.35
Azospirillum + K – Solubilizer	0.17 (1.08)	0.20 (1.09)	0.32 (1.14)	0.47 (1.21)	0.60 (1.26)	0.91 (1.37)	1.01 (1.41)	1.32 (1.52)	1.48 (1.57)	1.72 (1.64)	2.16 (1.77)	2.36 (1.83)	1.25 (1.49)	1.63 (1.61)	0.67 (1.29)	0.89 (1.36)	0.96	1.19
Azospirillum + Phosphobacteria + K – Solubilizer	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.01 (1.00)	0.03 (1.01)	0.23 (1.10)	0.19 (1.09)	0.31 (1.14)	0.33 (1.15)	0.41 (1.18)	0.41 (1.18)	0.51 (1.22)	0.19 (1.08)	0.36 (1.16)	0.00 (1.00)	0.21 (1.10)	0.14	0.26
Control	1.21 (1.48)	1.61 (1.61)	2.07 (1.75)	2.53 (1.87)	2.92 (1.97)	3.35 (2.08)	3.47 (2.11)	4.13 (2.26)	4.49 (2.34)	5.13 (2.47)	5.15 (2.47)	6.08 (2.65)	3.83 (2.19)	4.89 (2.42)	2.56 (1.88)	3.75 (2.17)	3.21	3.94
C.D. (p = 0.05)	0.04	0.07	0.07	0.10	0.11	0.09	0.09	0.09	0.08	0.09	0.08	0.10	0.10	0.12	0.08	0.14		

Each value is a mean of five replications
Values in parentheses are square root transformation

from three leaves, from the top, middle and bottom of each canopy, the plants were randomly chosen and tagged in each plot. The mean population per three leaves was calculated. From the time of their emergence until the last fruit of the crop was picked, observations were made at weekly intervals. The observations were recorded from 15 days after sowing (DAS) of the crop to final harvest in both seasons and expressed in numbers per leaf. Then, various Biophysical and Biochemical analysis were carried out to determine the resistance traits against *B. tabaci*.

3. RESULTS AND DISCUSSION

When evaluating the induction of resistance by agriculturally beneficial microorganisms in bhendi accessions against *B. tabaci*, revealed that the mean nymphal population was lowest in the accession Salem Local treated with K- solubilizer followed by the treatment *Azospirillum* + Phosphobacteria + K- solubilizer. Muthukumaran and Selavanarayanan [17] stated that among the tomato plants treated with bio inoculants *viz., Azospirillum*, Phosphobacteria, *Pseudomonas* and K-solubilizing bacteria, K-solubilizer treated plants recorded less feeding preference by *H. armigera* larvae. Similarly, Williams and Smith [18] noted that the K fertilizer is widely reported to decrease insect infestation in many host plants and it provides high resistance to insect pests. High K levels promote secondary chemical metabolism, which reduces carbohydrate buildup and plant damage from insect pests [19]. K solubilizer can solubilize potassium-containing minerals and convert insoluble potassium to soluble potassium, making potassium available for plant uptake [20]. The ability to solubilize the silicate rocks by various bio inoculants [21]. Adequate amounts of K have been reported to decrease the incidence of insect and mite damage considerably. Yellowish discoloration of plants suffering from K deficiency acts as a signal to attract aphids [22,23]. According to Marschner [24], Potassium (K) is the most essential for plant growth and metabolism. It also synthesizes high-molecular compounds that make plants more resistant to sap feeders. Sarwar [25] observed that, in many circumstances, plants with insufficient K seem to be more prone to infection than plants with sufficient K. The rate of rice borer infestation was greatest when there was no supply of K, but decreased rapidly as the K concentration increased. Similarly, Dedatta and Mikkelson [26] reported that the culm and stalk strength of rice was increased in the presence of adequate K concentrations as a result of increasing plant resistance. Ravichandran [27] observed that, chloride containing K fertilizer plays a leading role in plant resistance to herbivory. When plants were treated with K fertilization, red spider mite infestation on tomatoes and thrips colonization on linseed plants were both reduced. Aphid infestation in maize increased as a result of the K shortage. Prasad et al. [28] revealed that, adequate K increases phenol concentrations, which play a critical role in plant resistance. Furthermore, Sarwar [25] reported that, less pest damage in higher K plants can be attributed to a lack of pest preference under sufficient nutrient concentrations, as well as the synthesis of defensive compounds leading to higher pest mortality. Rani et al. [29] found that the variety IR 36 treated with the combination of biofertilizers like *Azospirillum,* Phosphobacteria and SSB recorded the lowest population of brown plant hopper and white backed plant hopper in rice. Among the treatments, the maximum nymphal population was observed in the accession Arka Anamika treated with *Azospirillum* in both *Rabi* and *Kharif* seasons (Tables 2 and 3). Mariana et al. [30] reported that inoculation with Azospirillum increase the supply of N by biological nitrogen fixation (BNF) process [31,32]. More nitrogen content can normally increase herbivore feeding preference, food consumption, survival, growth, reproduction and population density by altering the nutritional levels in the plant tissues and significant reduction of host resistance against insect herbivores [33].

4. CONCLUSION

When compared to other treatments, the accession Salem Local treated with K-solubilizer was found to be resistant to *B. tabaci*. Based on these findings, it could be concluded that resistant accession, Salem Local treated with K- solubilizer may be exploited in the breeding program to develop resistant varieties.

ACKNOWLEDGEMENT

The author is highly thankful to Department of Entomology, Faculty of Agriculture, Annamalai University, Annamalai Nagar, Cuddalore, Tamil Nadu for the technical support for conducting the research work.

COMPETING INTERESTS

The authors declare not to have any competing interest regarding the publication of this work.

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